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Renewable Energy Analysis for Strategic Responsiveness 2

Draft Report

Sponsor: G4 :
Logistics Integration Agency
LOIA-ML

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Agenda

- Purpose
- Background
- Objectives
- EEAs and MOEs
- Case Studies - Data and Analysis
- Insights
- Accomplishments
- What Next

Purpose

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To continue the analysis of deployable photovoltaic (PV) systems in support of various Army unit and installation missions. The Renewable Energy Analysis for Strategic Responsiveness (REASR 2) will examine issues regarding PV and strategic logistics, economics and operational readiness.

REASR
June 2000 – April 2001

- ✓ **RIMPAC, Pohakoloa Training Area**
- ✓ **Field Training Exercise, Ft. Bragg**

REASR 2
April 2001 – December 2002

- ✓ **Marne Focus, Ft. Stewart**
- **Phx, Ft. Irwin**
- **V Corps, 18th MP BDE, 709th MP BN, Hanau, GE**

Review of 3 Initial PV Demos (REASR)

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June 2000 – April 2001

Case Study No 1.

June 2000: RIMPAC 2000 Phase II Hotel; **H**umanitarian **A**ssistance **D**isaster **R**elief (HADR) Demo of Army's 1st Solar PV Generator.

US Army 25th Division

US Navy 3rd Fleet

USMC 6th MEF

Her Majesty's Royal Navy

Royal Canadian Navy

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Case Study No 2.

February 2001: Ft. Bragg Two, 3kW PV units provided to 1st BDE

Case Study No 3.

April 2001: Ft. Stewart.
Two, 3kW PV units provided to Marne Focus FTX

Background: Army Policy

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Public Laws:

Pollution Prevention Act of 1990...established a hierarchy for pollution management as national policy - declaring that pollution should be prevented or reduced at the source

Energy Policy Act (PL 102-486 - EPACT) ... enacted to increase the use of renewable energy and energy efficiency in the industrial, commercial, residential and Federal Sectors of the economy

Executive Orders:

12759 Reduction in Energy Use (4/91) ...Establishes energy efficiency goals for federal buildings / facilities and industrial processes.

12856 Pollution Prevention Requirements (8/93) ...establishes goals in the federal sector for pollution prevention

13123 Greening the Gov't Through Efficient Energy Mgmt (6/99) ...through *cost effective investment in energy efficiency and in*

Energy Technology Comparison

Generation of Electricity

Category	IC Engine	Gas Turbine	Photovoltaic	Wind	Fuel Cell
Capital Cost ($/kW)	200 - 350	450 - 870	**6,600**	1,000	3,750 (est.)
Size Range (power)	50kW – 5 mW	25kW – 25 mW	1kW – 1 mW	10kW – 1 mW	200kW – 2 mW
Efficiency (%)	35	29 - 42	6 - 20	25	40 - 57
O & M Cost ($/kWh)	.03	.005 - .007	**.0001 - .0002**	.01	.01 (est.)
Deployable Today?	Yes	Yes	Yes	Yes	No
Pollutant Problems?	Yes	Yes	No	No	Yes
Technology Status	COTS	COTS (above 25K)	COTS	COTS	Special DEMOS

How the Hybrid PV System Works

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16’

10’

3kW PV Array

22 cubic feet (folded), 250 lbs

Legend: Primary Power Flow

Backup Power Flow

4’ x 3’ x 2’ (24 ft³, 250 lbs.)

Battery Bank

Power Inverter

Primary

4’ x 3’ x 2’ (24 ft³, 1200 lbs.)

5kW GENSET

4’ x 3’ x 3’ (36 ft³, 650

Backup

Army Photovoltaic (PV) System

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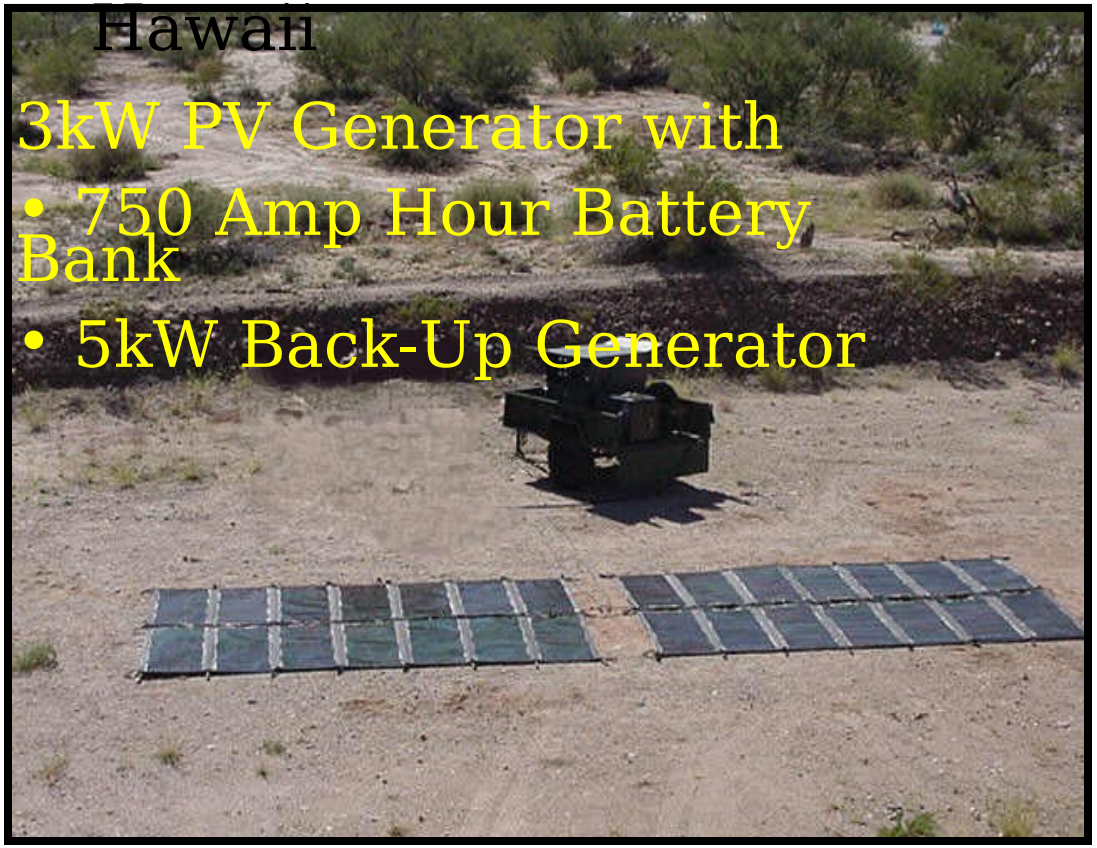
Demonstration Prototypes

As a result of the Analysis of Deployable Applications of Photovoltaics (ADAPT), deployable PV generators have been acquired for Army demonstration and analysis by the Army at Ft. Bragg (plus deployments), Europe and Hawaii

PV Analysis:

- Operational
- Economic
- Environmental
- Energy



Data & Analysis

- US Military Deployments (REASR 2)
  - Strategic Responsiveness
  - Operational Readiness
- Solar Radiation (10 year average)
  - National Renewable Energy Labs (Modeling Support
  - Data Logger
- TACS Deployment Analysis
  - National Training Center (Ft. Irwin, CA)
  - Germany (Fleigerhorst Kasern)
- Power Consumption
- Energy Savings
- Pollution Savings
- Economic Issues and Challenges

U.S. Military Deployments: 1990 - 2000

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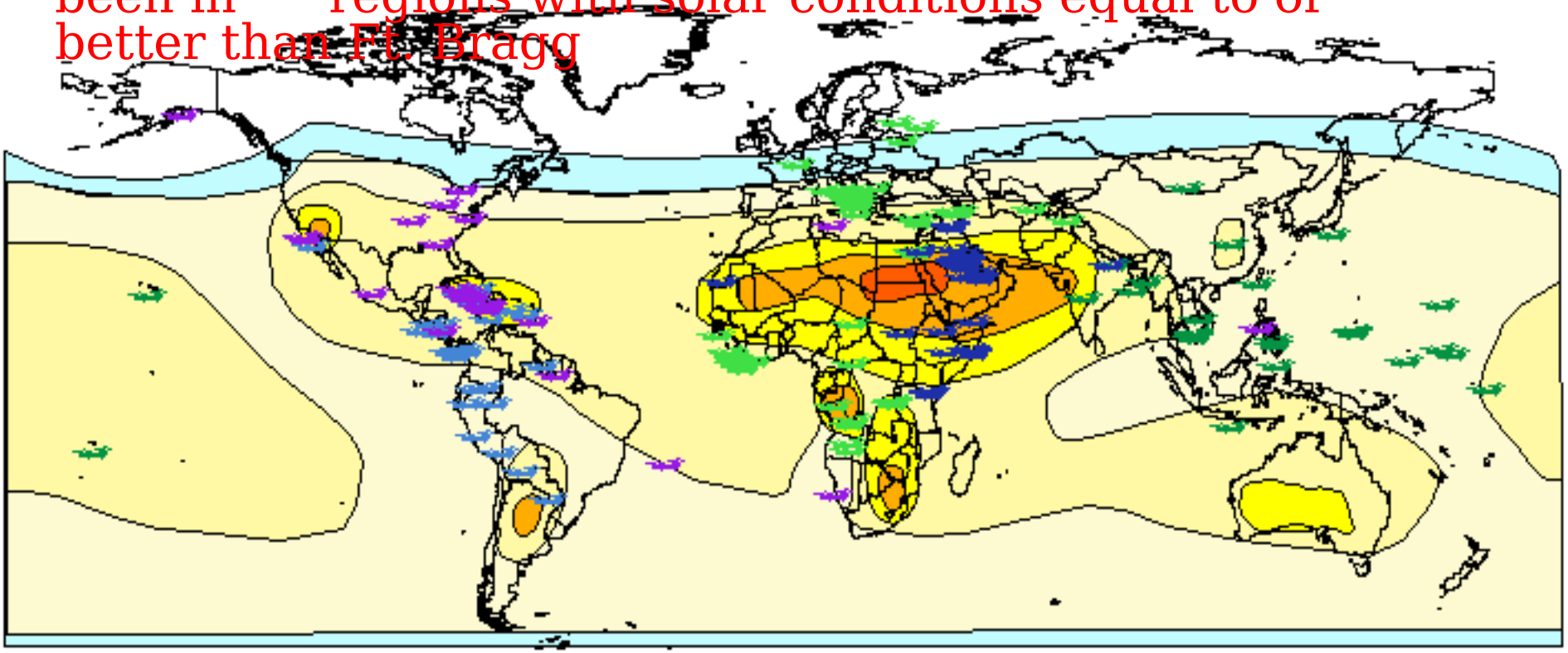
Two-thirds of Smaller Scale Contingencies (SSCs) have been in regions with solar conditions equal to or better than Ft. Bragg



Average annual solar radiation (Tera watt hrs. per year per square Km.)
Period: 1989 - 1999

Deployments
- ACOM
- CENTCOM
- EUCOM
- PACOM
- SOUTHCOM

World Radiation
- 2.55
- 2.32
- 2.09
- 1.85
- 1.62
- 1.39

TACS Strategic Responsiveness

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1. Strategic:

- TACS airlifted from Davis-Montham AFB, Martinsburg AFB, Dover AFB and Ramstein AFB (to other OCONUS destinations). TACS was up and running (without waiting for fuel) the same day upon reaching its destination(s).
- Load plans have been developed which include requirements for safe handling and shipment (e.g. empty fuel tanks, disconnected battery power cables)

2. Operational:

- PV TACS was deployed to NTC with 3/504 82nd AB (Ft. Bragg, NC to Ft. Irwin, CA), Kosovo with 709th MPs, Ft. Stewart, Georgia with 1/504 82nd AB, remote gate-guard missions at Fleigerhorst Kasern with 127th MP Company.

3. Tactical:

- TACS used for battalion level TOC power for GWAT missions in Afghanistan and Kosovo (REASR 3).
- CPX exercises in CONUS (Ft. Bragg, Ft. Stewart) where non-interruptible power capabilities of the PV TACS were noted

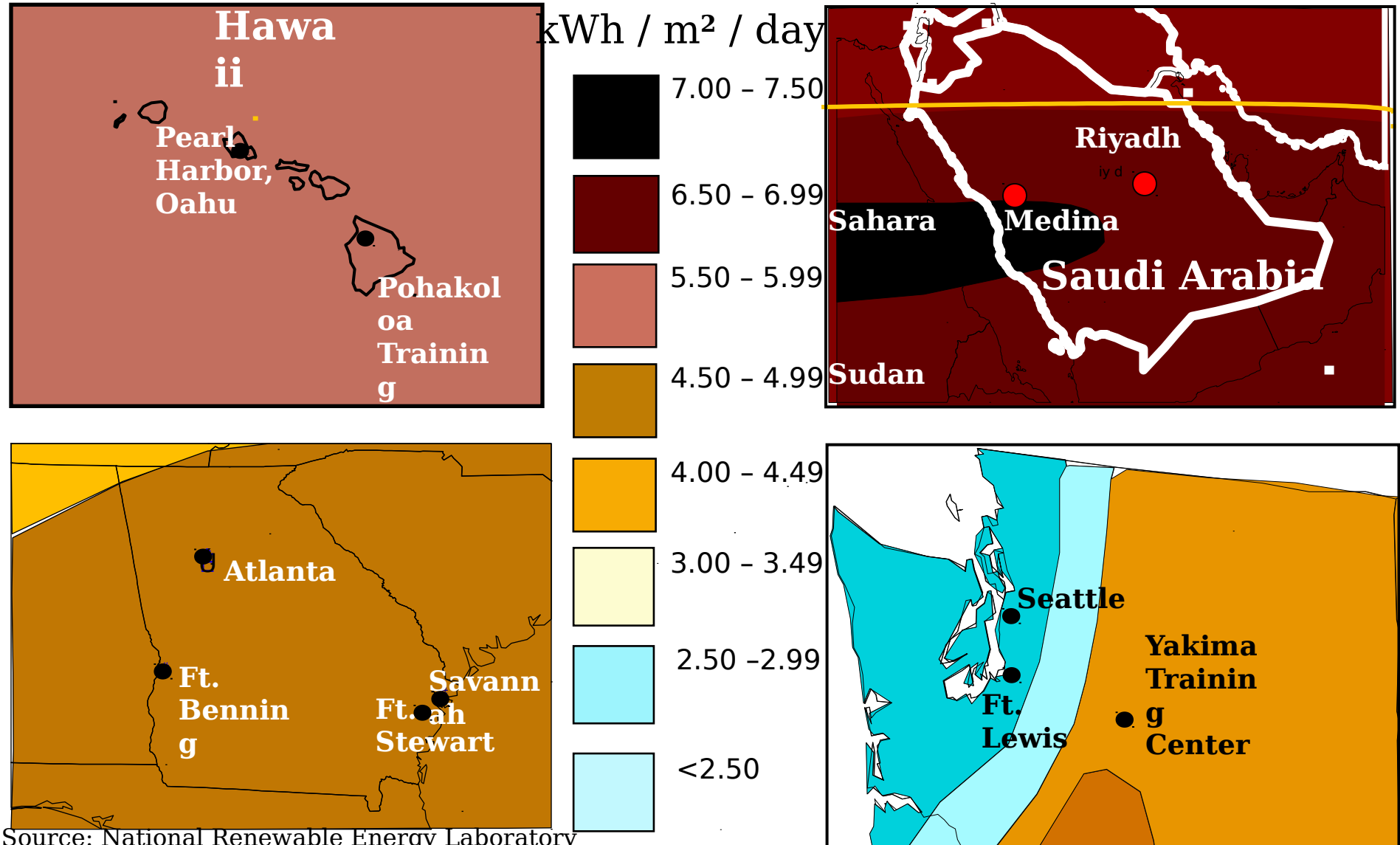
TACS Strategic Deployments

1. Strategic Deployments of TACS to:
   - Germany (18th MP BDE)
   - Bosnia (709 MP Bn)
   - Afghanistan (82nd Airborne, Ft. Bragg)
   - Kuwait (V Corps[1])
2. Strategic Lift Load Plans
   - Air National Guard
   - USAF

[1]See REASR 3 Study Report (to be published in August '03) for details

Localized Solar Radiation Data

Average Solar Insolation Over The Past 10 Years



Source: National Renewable Energy Laboratory

Predicted GENSET On-Time

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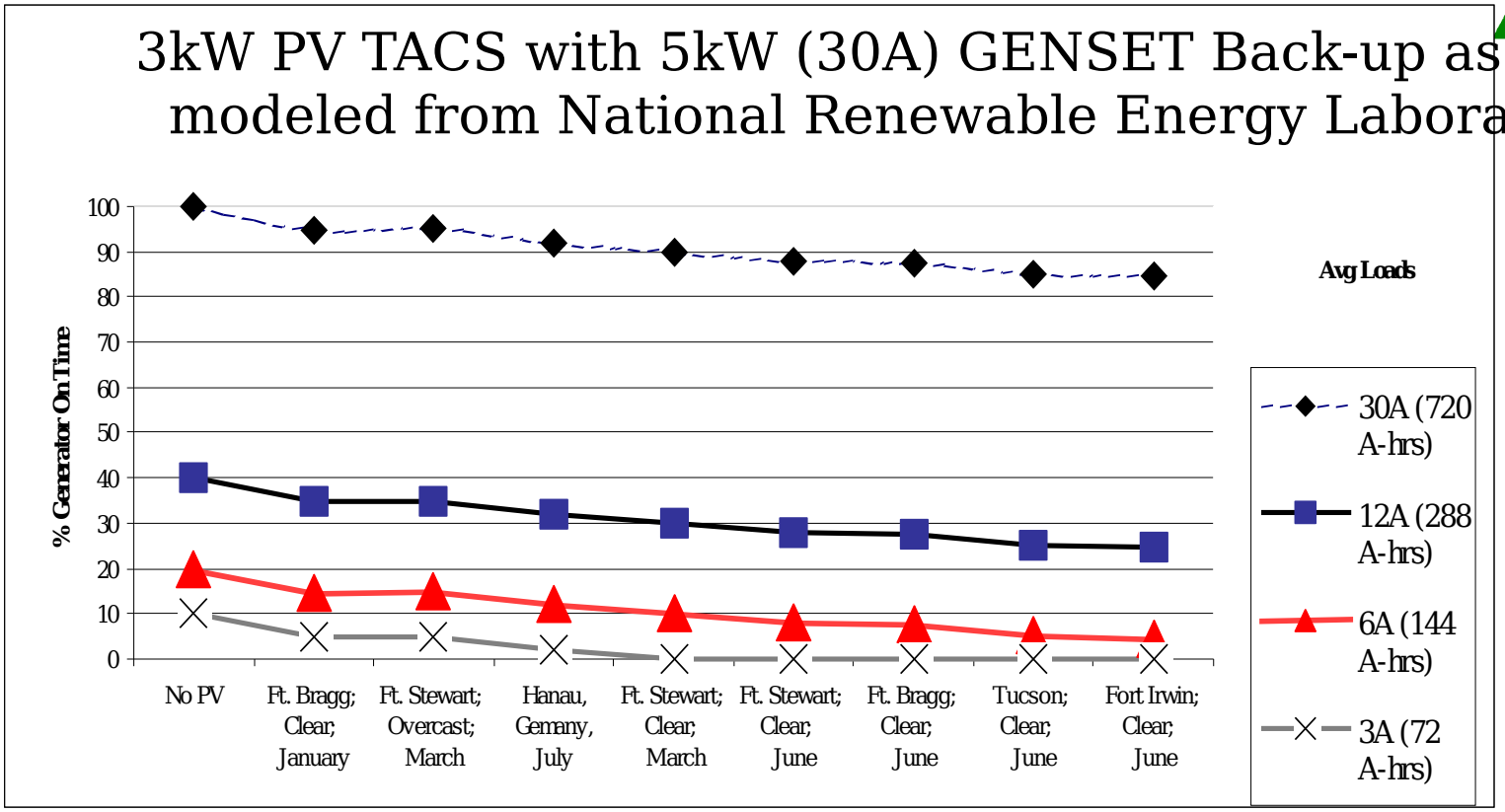

- Array sizing was performed to provide a target of 6 amps (continuous) from 6% PV efficient material (see red-line above)
- Should expect target of about 5% GENSET on-time at Ft. Irwin
- Should expect target of about 12% GENSET on-time at Hanau, GE

Data Loggers

- First order data was collected from on-board data loggers, accessible by telephone from most demonstration location locations
- The data is gathered as a function of time and stored in a mass storage media onboard the PV System.
- Data included
  - Solar radiation
  - Battery bank state-of-charge
  - On / Off fossil-fuel generator times
  - System electric load measured in amps
  - Elementary weather data
- This data was collected and used for the analysis of “on and off” GENSET times in the Fleigerhorst Kasern and NTC demonstrations

Analysis of Photovoltaic System at Ft. Irwin, CA June 7-20, 2001

Synopsis of Ft. Irwin Demo

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Events

1. June 2001, 1 / 504 rail hauled PV systems to NTC from Ft. Bragg
2. Noted problems with trailer off-loading from rail (see photos)
3. Mechanical problems reduced mobility of PV system
4. Employed PV systems for 2 weeks:
   - BN TOC Power
   - Demo for BDE TOC Power
5. High winds made arrays “kite” (troops developed on-site fix which was later refined with tie-downs)
6. 3rd week of July, rail-shipped PV system back to Ft. Bragg (no further damage reported)

Ft. Irwin Demo Data

System Load: June 2001

National Training Center (NTC) Rotation

Description	Voltage (VAC)	Current/Min* (Amps)	Power (Watts)	Current/Max* (Amps)	Power (Watts)
Battery charger	115.0	2.5	288	2.5	288
Laptop computer	117.0	0.5	59	0.8	94
Laptop computer	117.0	0.6	70	0.8	94
Laptop computer	117.0	0.6	70	0.7	82
Copier	117.0	1.2	140	8.0	936
Charger+Adapter	116.0	0.5	58	2.6	302
Heater[1]	118.0	10.8	1274	14.3	1687
Printer	118.0	0.1	12	0.3	35
8 lights	113.8	3.7	421	3.7	421
Coffee maker	106.8	1.2	128	10.8	1153
Total Amps		21.7		44.5	

- Without the heater, steady-state load averaged 5.3 amps continuous over the 14 day exercise (close to the target of 6 amps – see chart 19: Predicted GENSET "On-Time")
- 100% increase in system load possible at initial start-up

[1]Heat was run from IP8 fed stove after day 3

Color indicates systems that require high

GENSET vs. TACS On-Time

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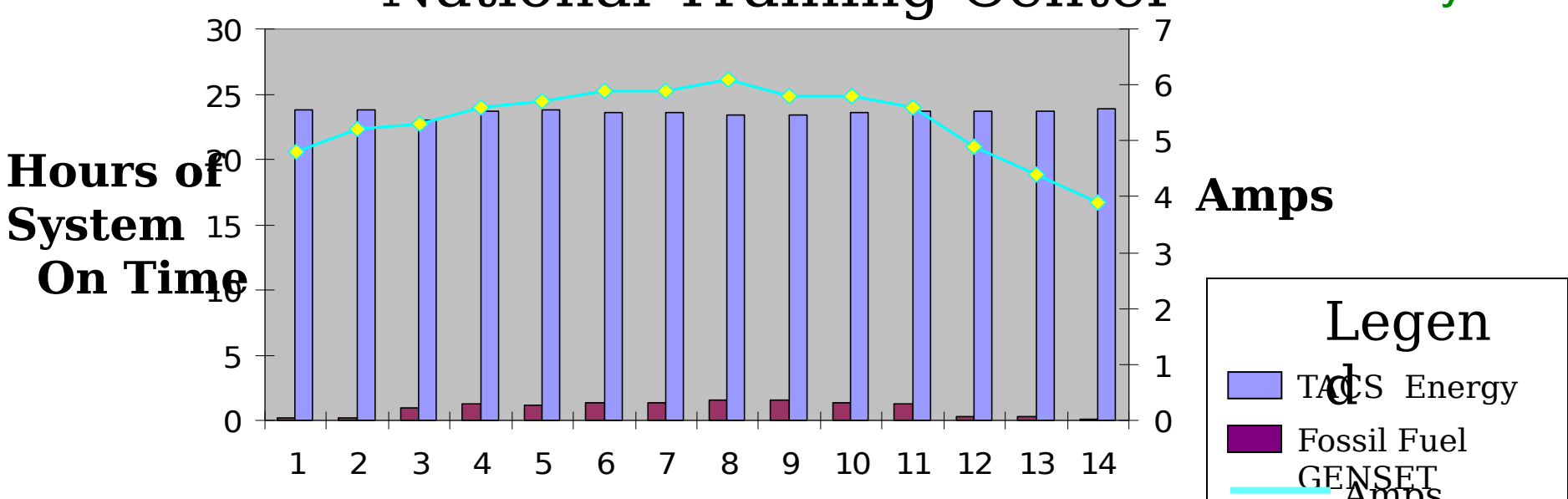
National Training Center



- 13.3 hours of GENSET on-time over 336 hour exercise (3.9%)
- Average Amps of 5.3 (per day) were less than targeted range of 6 amps
- 5kW GENSET consumes ½ gal JP8 / hour
  - Exercise of 336 hours would use 336 X .5 = 168 gals of JP8 with no TACS
  - 13.3 hours of GENSET on-time consumed 13.3 X .5 = 6.7 gals JP8 with TACS

TACS employment saved 161 gallons of JP8 (96% fu

Case Study #4: Ft. Irwin Findings

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- 3kW PV System was sole power source for airborne regiment's tactical operations center (TOC, briefing tent)
  - Troops appreciated that the stored battery bank energy provided immediate power to the TOC without waiting for JP8 to arrive at their remote site
- Provided tactical quiet for security missions (zero decibels)
- TACS provided power for 96% of the exercise, GENSET 4%.
- Problems with TACS noted
  - M101 trailer shock absorbers destroyed at NTC rail yard and axle bent
  - High winds caused PV array to "kite"
- Fixes to problems:
  - Follow standard materiel offloading procedures
  - Tie downs supplied with future PV arrays
- No bad weather except for high winds
- Saved an average of 12 gals of JP-8 /day (TACS was alternate for 5kW Tactically Quiet Generator)
  - Estimated yearly OPTEMPO fuel savings: 800 gals.

Economic Analysis

- Cost Factors (Parametric Analysis)
  - Initial System TACS and Fossil Fuel Generator Costs
  - Operations and Maintenance Costs (O & M)
    - Direct and general support costs for generator repair were based on the Logistics Integrated Database (LIDB)
    - Operations costs were provided by the Project Manager's Office for Mobile Electric Power
  - Labor Costs (based on wage board civilian (i.e. non-military, pay scale)
  - Replacement Costs
  - 20 Year Fuel Inflation Costs
- Net Present Value (20 year life cycle costing)
- Payback (years)

Base Assumptions

- OPTEMPO = 1600 hours per year
- Fuel is always available (and tested)
- 20 year life-cycle costs for TQG with replacement at years 5, 10 and 20
- 20 year life-cycle costs for PV
- Discount PV initial cost by 30%, 40%, 50%
- Ft. Bragg Ambient Conditions
- FY02$
- Cost of fuel is $.76 / gal (Defense Energy Support Ctr)

TQG and Photovoltaic System Cost Comparison

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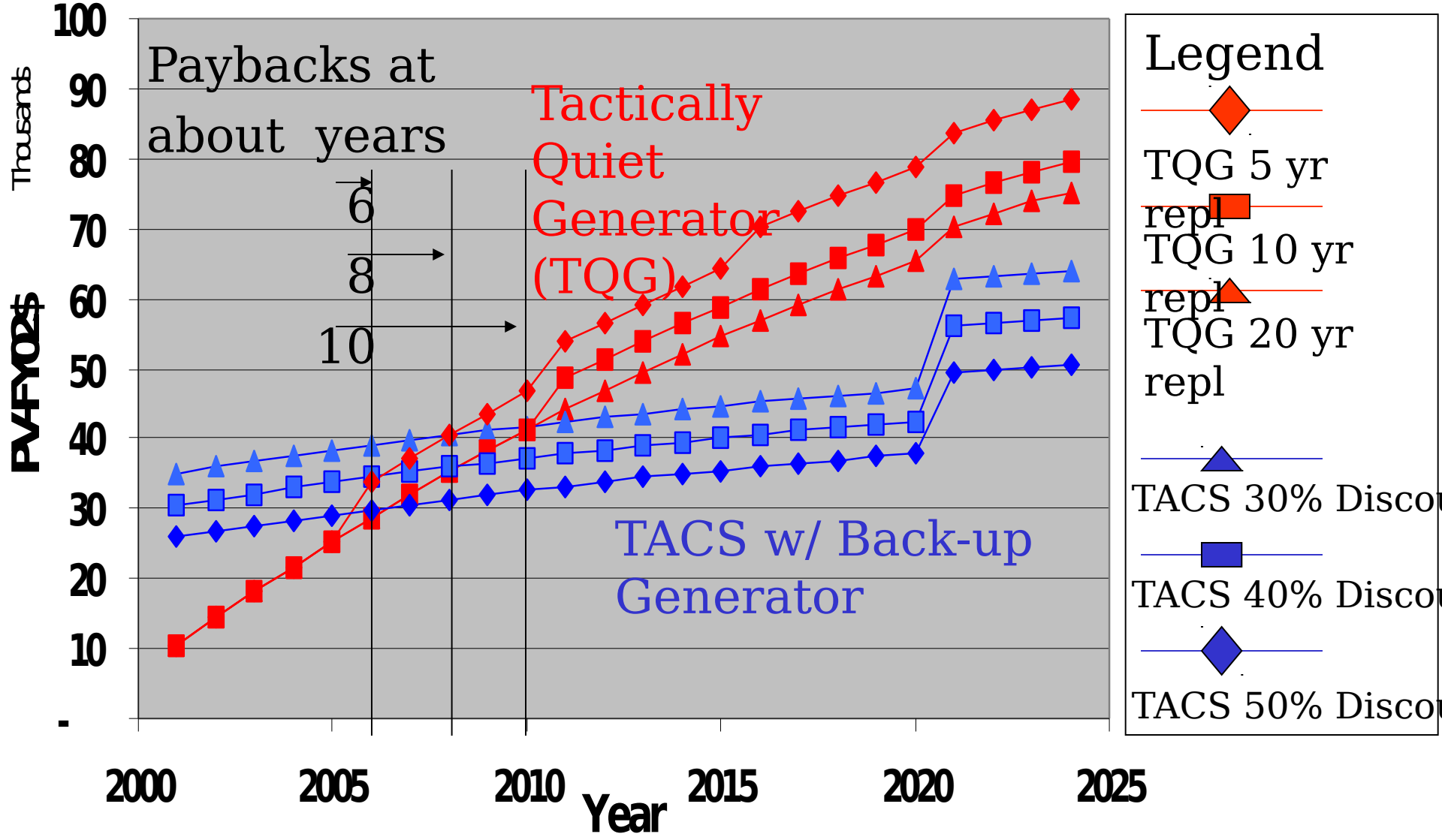
Cumulative Net Present Value of Cost Avoidance

Fuel cost for CONUS OPTEMPO training is DESC Cost $.76 Ga



New Fuel Cost Assumption

- OPTEMPO = Deployed = 1600 hours per year
- Fuel is always available (and tested)
- 20 year life-cycle costs for TQG with replacement at years 5, 10 and 20
- 20 year life-cycle costs for PV Array (sub-element of the TACS)
- Discount PV initial cost by 40%, 50%, 60%
- Ft. Bragg Ambient Conditions
- FY02$
- Fuel cost delivered to FEBA is $13/gal[1]

[1] Fuel cost from Defense Science Board report "More Capable Warfighting Through Reduced Fuel Burden" May 2001

TQG and TACS System Real Fuel $ Comparative Net Present Value of Cost Avoidance

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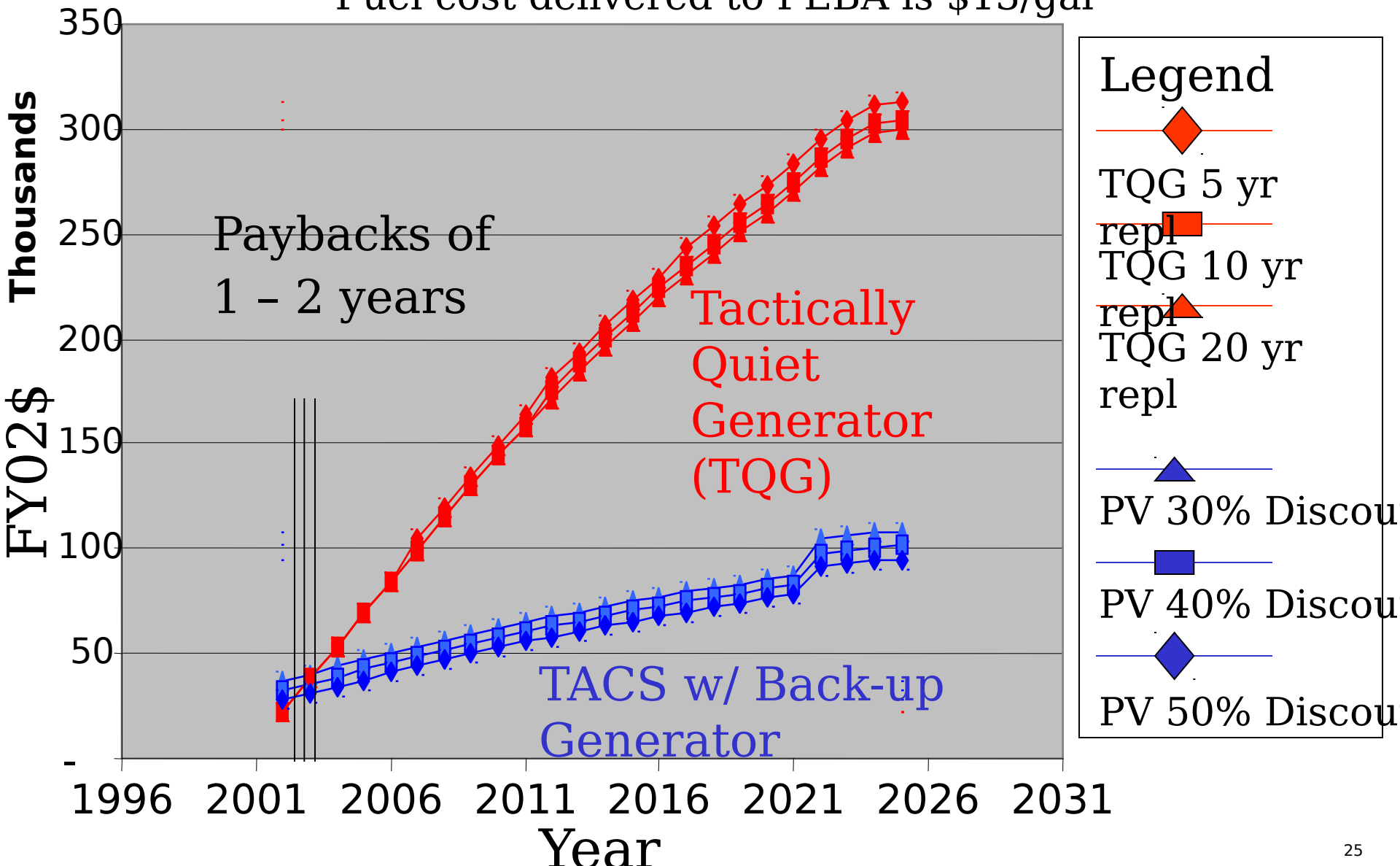
Fuel cost delivered to FEBA is $13/gal[1]



Economic Analysis Findings

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TACS Paybacks Based on Net Present Value, FY02 $$$

High Payback
10 Years
6 Years

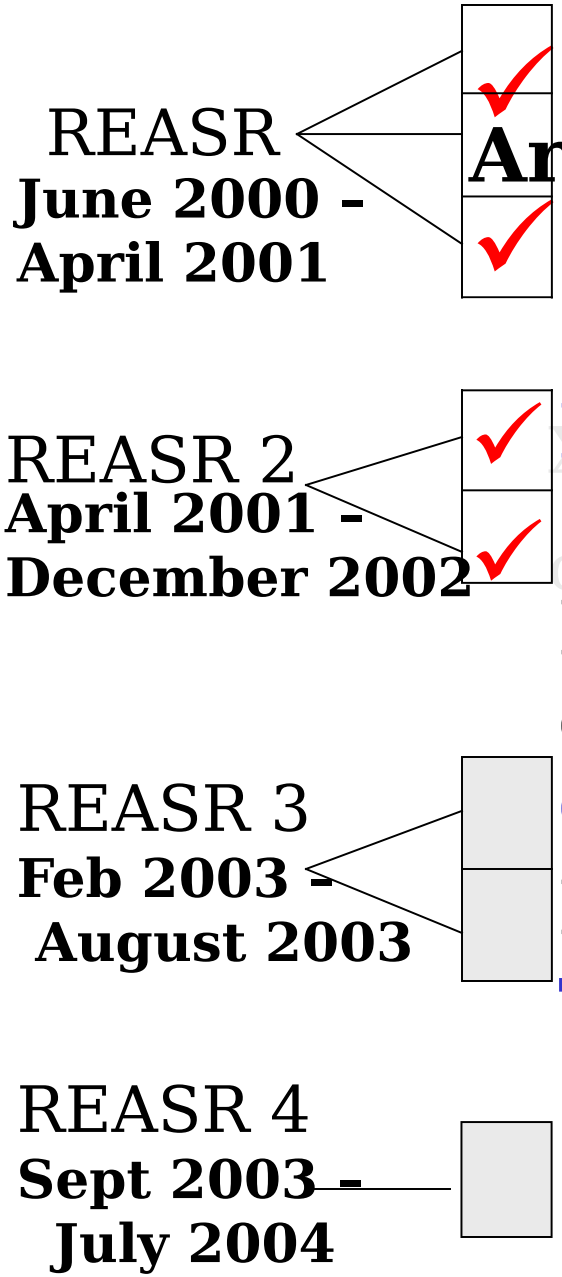
Most Likely Payback
8 Years

Low Payback

Costing Challenges:

- TQG Operations and Maintenance Costs and Initial System Costs are the primary factors in the payback analysis. (including the "increased costs" of advanced fossil-fuel power generation would decrease the paybacks shown above by 1 to 2 years)
- Military deployments pay increased costs per gallon for delivered JP8 to and beyond the FEBA. This increased cost drives the paybacks for TACS down to 1 or 2 years.
- Future Costing Issues:
  - 20 year fuel inflation costs - although updated for this particular study - fuel costs can change significantly from year-to-year. FY99 = $.87/gal, FY00 = $.62/gal, FY01 = $1.01/gal, FY02 = $1.34) This continued instability will make TACS systems more attractive to big consumers of fossil fuels in the long run

What Next



RIMPAC, Pohakoloa Training Area

FTX, Ft. Bragg

Marne Focus, Ft. Stewart

FTX, Ft. Irwin

V Corps, 18th MP BDE, 709th MP BN, Hanau, GE

GWAT, V Corps, Cmd Gp, Kuwait

Ft. Lewis / Yakima Training Ctr, DPW

Site To Be Determined (AAMPS and / or DMFC